Marketing Research Report No. 700

MECHANIZED WEIGHING AND PACKING OF BROILER PARTS TO EXACT WEIGHTS

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service
in cooperation with
UNIVERSITY OF GEORGIA—College of Agriculture Experiment Stations

PREFACE

This report on mechanized sizing, weighing, and packing of chicken parts to exact predetermined package weights is based on a continuation of studies of the relationship between weights of chicken carcasses to their various parts reported in Marketing Research Report No. 604, "Relations of Weights and Sizes of Broiler Parts to Carcass Weights." The experimental mechanical equipment for this project was developed, under a marketing research contract, by the Gordon Johnson Company, Inc., Kansas City, Mo., and was tested in the J. D. Jewell, Inc., poultry processing plant in Gainesville, Ga.

The work is part of a larger research project covering the development of improved work methods, equipment, and facilities for processing poultry and poultry products engaged in jointly by the Agricultural Research Service, U.S. Department of Agriculture, and the University of Georgia, College of Agriculture Experiment Stations.

General supervision of the work was by John A. Hamann, investigations leader, Transportation and Facilities Research Division, Agricultural Research Service, U.S. Department of Agriculture.

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SUMMARY

A device to mechanize the weighing of chicken parts for packing to predetermined package weights was developed and tested under commercial operating conditions. The purpose of mechanizing the weighing operation was to reduce both the high labor requirements for manual weighing and packing of chicken parts and the amount of product lost in overweight packages in manual operations.

The experimental machine accomplished both these aims, but the tests showed there are disadvantages as well as advantages in the mechanized operation.

The average weight above the marked net weight for packages filled on the experimental equipment was 0.12 ounce, and 0.59 ounce for packages filled by manual methods. Projected to a 10,000-pound-per-day operation, the increase in accuracy shows a potential for savings of approximately $100 per day, using an average price of 35 cents per pound for chicken parts. Time studies indicated that labor requirements for packing could be reduced by about 35 percent with the experimental equipment.

Although these improvements are of great significance, a number of difficult problems remain. Design and use of the machine were based on packing parts from carcasses sized to a 4-ounce weight range, because this sizing provides parts in a predictable weight range. Not all lots of chicken carcasses, however, provide a balanced number of parts in the expected weight range.

The test results favor consideration of mechanized weighing of chicken parts to meet exact weight packing requirements for large-scale operations where a wide weight range of chicken parts could be used. The equipment would probably also be useful for selecting chicken parts for institutional portion-control packs, in which all parts must be about the same weight.

MECHANIZED WEIGHING AND PACKING OF BROILER PARTS TO EXACT WEIGHTS

By Rex E. Childs and Roger E. Walters [1]

Transportation and Facilities Research Division, Agricultural Research Service

BACKGROUND OF THIS STUDY

The poultry processing industry marketed 7.5 billion pounds of broiler-fryer chicken meat in 1964. About 20 percent of this volume (over 1 billion pounds) was processed beyond the form of whole, ready-to-cook chicken; most of it was frozen chicken parts packaged separately as wings, drumsticks, thighs, breasts, or backs. Some of the parts were packed into consumer packages (exactly 1, 2, or 5 pounds, and so forth) and some as institutional or portion-control packs (10 or more pounds), in which all pieces are about the same size.

Further processing the whole chicken and packing the parts into packages increases the unit cost to the consumer over that for whole chickens. The labor required per pound or unit of output increases about 10 times; additional plant facilities are required, including freezers and refrigerated warehouses; a larger volume of product and a greater variety of packaging materials must be kept in inventory; and the processor must make up for the cost of an actual loss of up to 3 percent of the original carcass weight because of moisture weepage and overweight packages.

The consumer demand continues for these especially prepared and packaged products even at the increased cost over whole, ice-packed poultry, and the market would undoubtedly expand even more rapidly if the costs of further processing could be reduced.

There are many advantages to the processor in cutting up and packaging at least a portion of the plant's production. Three main advantages are: Carcasses that must be downgraded because of trimming requirements can be cut up and the unaffected parts can be sold without a quality penalty; when a substantial percentage of the chicken processed is sold in frozen form, it can be stored and shipped with less concern for quality deterioration, making production schedules more stable; and poultry packaged in easy-to-use form and in a wider range of choices (light or dark meat) helps increase consumption of poultry meat.

One of the more costly operations occurs in the packaging of parts to an exact premarked net weight (such as 1-, 2-, or 5-pound packages of drumsticks).

The packaging of chicken parts could be greatly simplified if a specified number of pieces were packed in each box, rather than a specified net weight. However, there are at least two primary reasons for packing to predetermined net weights. First, it simplifies inventory control if packages are a standard known weight; and, second, the retail store operator prefers packages of the same weight for simplicity in pricing the product.

The high cost of this extra service is due largely to relatively high labor inputs and loss of product through overweight packages. Research was directed toward reducing these costs. A machine was developed and tested to explore the possibilities of mechanizing the weighing and selecting of chicken parts to an exact weight to reduce labor requirements and minimize the amount of overweight that occurs intermittently in the manual operation.

MANUAL METHODS OF PACKAGING PARTS

It would be difficult to arrive at a typical packing station layout and a typical method for packaging parts in the poultry processing industry. Peculiarities of each plant, such as volume of product cut up, form of final product, ingenuity of plant management, and space available for the further processing, influence the methods, equipment, and station layouts used.

When whole chickens are used in packing parts, carcasses are first sized to yield combinations of parts that can readily be packed in packages of exact weights. For example, carcasses that will

[1] Mr. Walters has been transferred from the field station at Athens, Ga., to the field station at Davis, Calif.

yield six drumsticks to a pound would be selected for the packaging operation at one time, and carcasses yielding nine drumsticks to a pound at another. More difficulty is encountered in packaging exact weight packages from chickens with parts trimmed off because the carcasses cannot be accurately sized before being cut up.

The trial and error method of weighing chicken parts to exact net weight is in common use in a large number of plants. The packing station is equipped with a small platform scale of the over-and-under dial type.[2] The packer places the desired number of parts in a container and notes the amount of excess or shortage. She then exchanges pieces in the package with those in a stock supply until the proper net weight is attained. This can be a time-consuming operation, since as many as seven or eight pieces may be tried before the desired combination of parts provides the correct weight.

Directly affected by the trial and error weighing technique is the ever-present problem of package overweight. Unless close supervision is exercised over this type of weighing operation, the monetary loss can be serious. Normally, the operator is instructed to pack to within an overweight tolerance range maintained for the part being packaged. If the parts do not easily provide good weight combinations that fit the specified package, the operator is generally inclined to pack over the tolerance range, giving away a considerable amount of meat during a normal packing period.

Data from several plants are tabulated in table 1 to illustrate the problems of overweight and underweight packages. These figures are averages for the entire lot and do not reflect the wide variation between packages in each lot.

A direct relationship between the columns of figures can be seen in most of the test lots. Where a large percentage of packages were underweight, the excess poundage was low and vice versa. Weights and measures laws allow some packages of a sample lot to weigh less than the net weight indicates so that the average package weight will be on or slightly above the minimum weight, but excess variation between packages or uniformly light or extra heavy weight is not permitted.

The weighted average overweight per package for all lots shown in table 1 is just over one-half ounce. Considered on a single package basis, the loss is insignificant. If the average excess weight in 1 million packages, however, amounts to only one-half ounce per package, the loss to the processor approximates $10,000. Ten times this volume is not an unusual annual output of some processing plants that process parts.

[2] This scale has a counterbalance equal to the package weight. The dial registers zero when a package equals the counterbalance weight. If the package weighs more or less, the dial shows the overage or shortage.

TABLE 1.—*Weight variation in packaged poultry parts*

Chicken part	Marked net weight of package	Packages in sample	Underweight		Overweight		Net overage or shortage per 1,000 packages [1]
			Packages	Total	Packages	Total	
	Lb.	*No.*	*No.*	*Lb.*	*No.*	*Lb.*	*Lb.*
Drumstick	1	40	0	0	39	2. 37	59. 37
Do	1	83	5	0. 25	78	3. 62	40. 62
Do	2	94	32	. 60	62	. 72	[2] 1. 25
Do	2	100	44	. 27	56	. 33	[2] . 63
Do	1	103	19	. 05	84	1. 03	10. 00
Whole leg	2	102	7	. 09	95	8. 06	78. 12
Split breast	2	100	10	. 20	90	6. 14	59. 37
Do	2	100	37	. 36	63	2. 80	24. 37
Whole breast	1	100	8	. 32	92	5. 25	49. 37
Thigh	1	30	0	0	29	1. 56	51. 87
Do	1	101	0	0	101	5. 68	56. 25
Wing	1	90	0	0	90	3. 09	34. 37
Total		[3] 1, 043	162	2. 14	879	40. 65	

[1] This column reflects the net overweight or shortage per 1,000 packages for each lot, assuming the sample was representative.
[2] Sample lots had a high percentage of underweight boxes that varied considerably from the labeled weight.
[3] Includes 2 packages of exact weight.

RELATIONSHIP OF CHICKEN CARCASS WEIGHT TO WEIGHT OF INDIVIDUAL PARTS

Since the most common method of presizing chicken parts is selection of carcasses by weight, the relationships between carcass and parts weights were investigated. Laboratory studies showed a significant relationship did exist.[3] The results indicated the possibility of predicting within a narrow range the weight of each chicken part from any given carcass, within the limits of single flocks of similar breed characteristics, if the method of dismembering is always the same.

In addition to laboratory tests, carcasses and cut-up parts were weighed in commercial processing plants to determine whether the laboratory results were applicable under varying plant conditions. Laboratory tests indicated that 95.2 percent of the drumsticks from carcasses sized within a 4-ounce range would fall within a 30-gram (1.06 ounces) spread. Field data used as a comparison (table 2) shows that an average of 97.6 percent of the drumsticks from hand-weighed carcasses fell within the 30-gram range. This verified that the laboratory data were sufficiently accurate for future predictions. The data in table 2 indicate, however, that there is variation between flocks since some of the lots had less variation than the laboratory tests, while others had more.

EXPERIMENTAL WEIGHING AND PACKING MACHINE

The laboratory and field studies data were so promising that steps were taken to design, construct, and test a machine for mechanizing the weighing and segregating of chicken parts for rapid packaging. The design and construction work was carried out by a private company under a research contract[4] that set forth the machine specifications and operating requirements. Tests of the prototype equipment were conducted by the U.S. Department of Agriculture.

The machine was designed primarily to weigh, segregate, and package drumsticks, because this part is the most uniform in size and weight. Restricting the machine to this one part also made it less complex and less expensive. The design was intended for testing the principles of weighing and segregating chicken parts so that the operator could rapidly select and package parts that yielded net weights within a close tolerance range (0.2 ounce or about 6 grams.) Because laboratory tests and field data (table 2) showed that about 97 percent of the drumsticks from chicken carcasses sized within a ¼-pound (4 ounces) range would fall within a 30-gram (1.06 ounces) range, the machine was designed to weigh and segregate drumsticks.[5] The machine allowed for a difference of 30 grams between the heaviest and the lightest drumsticks.

TABLE 2.—*Percentage of drumsticks, taken from hand-weighed carcasses, falling within 30-gram [1] spread*

Lot No.	Lot size	Range in carcass weight	Drumsticks in 30-gram spread
	Birds	*Ounces*	*Percent*
1	13	4	100. 0
2	16	4	100. 0
3	11	4	100. 0
4	27	3	100. 0
5	150	3	97. 0
6	34	4	100. 0
7	12	4	91. 6
8	10	4	95. 0
Weighted average			97. 6

[1] 1.06 ounces.

Operating Principle of the Test Machine

The experimental machine was designed to weigh drumsticks and segregate them by 3-gram weight differences, and to designate the weight needed to fill out a package to the exact total weight required after an operator had packed all but the last part in a container.

The machine (fig. 1) consists of a parts classifier (weighing belt and platform) and a parts segregator (segregator belt, 11 bins to hold parts, and an air-actuated flipper mechanism that trips the part into the appropriate bin). A memory circuit is also part of the parts segregator, and a highly sensitive electronic scale (hand scale in the diagram) is mounted on the segregator.

To weigh and package parts with the machine, it was first necessary to determine the carcass weight ranges that would yield a specific number of drumsticks per pound. This was the key to successful machine operation, since machine and scale adjustment depended on the number of pieces per package. If six pieces per pound were

[3] Walters, Roger E., May, K. N., and Rodgers, P. D. Relations of Weights and Sizes of Broiler Parts to Carcass Weights. U.S. Dept. Agr., Mktg. Res. Rpt. No. 604, 30 pp. illus. 1963.

[4] U.S. Department of Agriculture Contract No. 12-25-010-2652, Designing an Experimental Chicken Parts Sizing and Packing Line.

[5] During the test, it was found that a modification of the scale platform design and resetting of the weighing range would permit accurate weighing and segregating of other parts.

AN EXPERIMENTAL MACHINE FOR WEIGHING AND PACKAGING CHICKEN PARTS

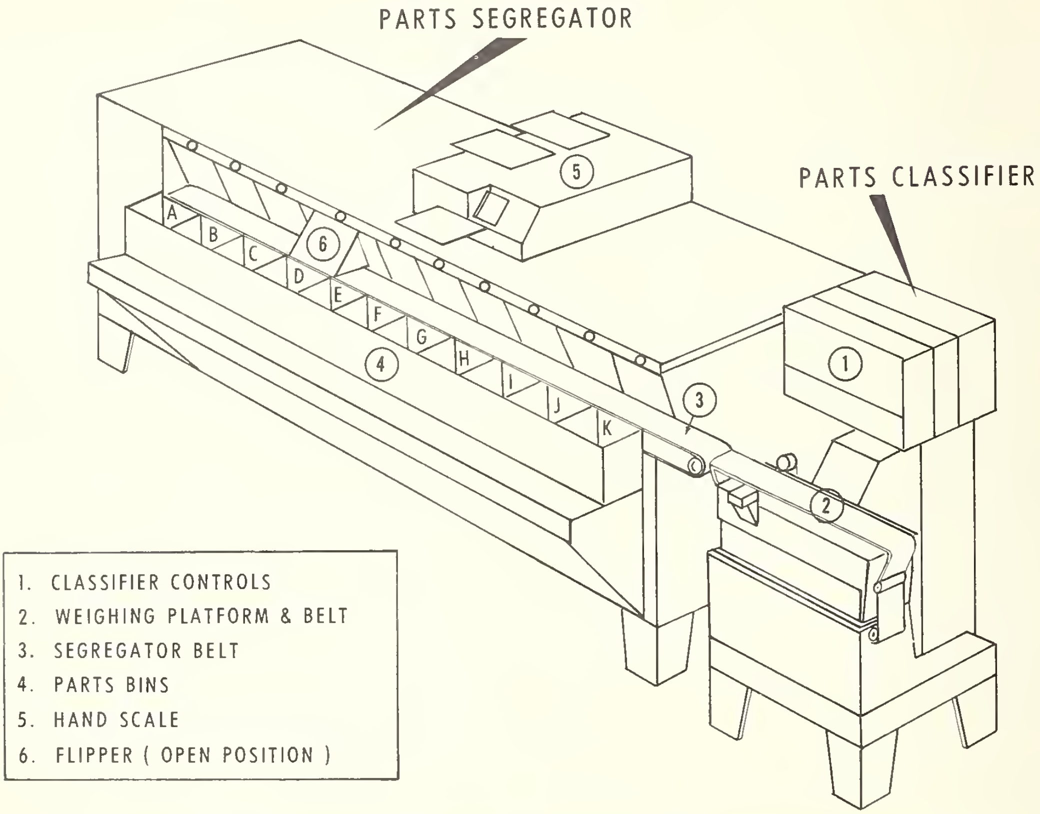

FIGURE 1.—An experimental machine for weighing and packaging chicken parts.

to be packaged, the machine design required that the average weight of the drumsticks being packaged must be near 1/6 pound; likewise, for seven parts per pound, 1/7 pound; and for eight parts, 1/8 pound and so forth.

The classifier scale was adjusted to trip all parts of mean weight into the center bin (fig. 1, parts bin F) as the parts proceeded down the segregator belt. This meant that for a six-parts-per-pound packing operation, for example, the weight variation in bin F was 74.1 to 77.1 grams (2.61 to 2.72 ounces). The other bin weights were set and "locked" in with the setting of the center bin, the lighter pieces to be deposited in bins A through E to the left of bin F, and heavier pieces to the right in bins G through K. The weight range of 3 grams allowed for each bin gave an overall spread of 1.16 ounces (32.8 grams) for the machine, a spread slightly greater than the variation expected for drumsticks from carcasses sized to 1/4-pound increments. All pieces lighter than this range fell into bin A, and those heavier than the weight range fell into bin K. In addition, any parts not deposited in the proper bin because of segregator malfunction were diverted into bin A automatically by a guide-rail-like baffle crossing the segregator belt. Thus, the parts' weights in bins A and K did not fall within a predictable weight range.

Specifically, the machine components function as follows: Parts are fed onto a supply conveyor (fig. 2, auxiliary to the weighing belt shown in fig. 1) in single file, end to end; the supply conveyor delivers them to the faster moving classifier weighing belt that spaces the parts sufficiently to permit accurate weighing; and while on this conveyor belt, they are routed across a weighing platform.[6] The platform length is 7½ inches. It weighs up to 55 drumsticks per minute. The weighing belt is a loose fitting, polyethylene type of material which allows practically the full weight of the part to bear on the weighing platform as it passes across. The parts classifier scale is adjusted to maintain weighing accuracy

[6] In a commercial model the supply conveyor would travel from a supply area to the classifier weighing belt. (Separate belts are required to avoid weighing inaccuracies.)

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FIGURE 2.—Drumsticks feeding off auxiliary (supply) conveyor, to classifier then to segregator.

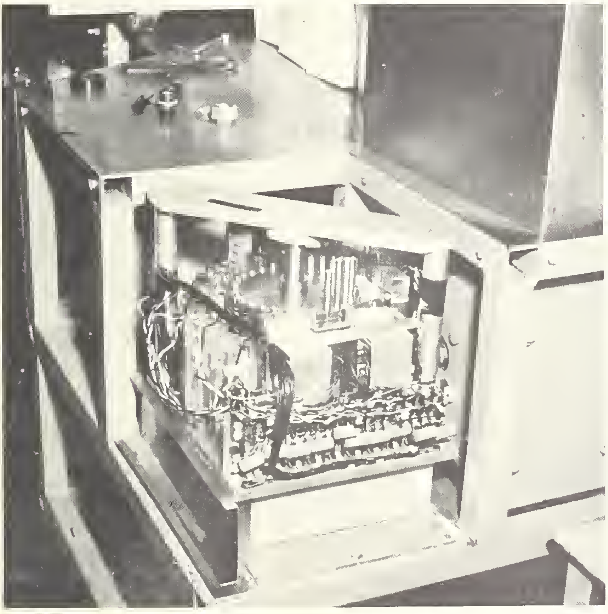

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FIGURE 3.—The memory unit (cover removed) of the parts segregator. This unit triggered the mechanisms for pushing the parts into the proper bins.

while the belt is in motion and to compensate for belt drag or friction. As a part leaves the classifier weighing platform, it passes through the beam of a photocell that registers its weight in the memory unit (fig. 3) and sets the parts segregator to discharge it at the proper position on the belt. Then, as the part reaches a point adjacent to the appropriate bin, the air-actuated flipper mechanism is triggered, pushing the part into the proper bin.

A worker selects parts from the bins and fills a container (set on a packing shelf in front of the hand scale, fig. 4) to within one piece of capacity. She then places the container on the hand scale and presses a switch button beside the scale platform (fig. 5). A signal circuit is activated and a light flashes over the bin from which a part of appropriate weight to fill out the container should be taken.

The hand scale or checkweigher is a highly sensitive electronic scale with counterbalance platforms. A counterweight is placed on the rear platform of the scale, and the boxes of chicken parts are weighed on the front platform. The signal light merely points out the weight differential between the counterweight and the partially filled box. The scale was set for operation with six pieces per pound. Packing other counts required adjustment of the counterweight.

The weight of the last part needed to complete a container depended on the worker's selection of parts in filling the container. Normally, parts would be selected from both sides of the center bin so that parts lighter than the mean weight

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FIGURE. 4.—Operator at packing station in front of checkweigher scale and packing platform.

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FIGURE. 5.—Operator presses a button switch that causes a signal light to flash on over the bin from which the last part should be taken to bring the net weight of the package to the desired marked weight.

would offset the heavier ones selected. In making up a six-parts package, for example, one part could be taken from bin D, two from bin E, and two from bin G. If in this case the mean weight of the parts in bin F was 2.66 ounces, the combination selected would weigh about 13.1 ounces, and a part weighing 2.9 ounces would be required to make up a 1-pound package. The signal circuit would point out bin H or I for selection of the last part, depending on the variation of the parts in the package from the mean weight of the bins from which they were selected.

The worker could make up packages by taking parts from other bins on both sides of bin F or by taking parts only from bin F.[7]

The machine design requirements called for a weight tolerance of 0.2 ounce (approximately 6 grams) per package. Therefore, the target weight was set for 0.1 ounce (3 grams) over the marked net weight of the package. Theoretically then, the minimum weight of meat put into any package would be the package net weight, and the maximum would not be more than 0.2 ounce greater than the minimum. Any desired weepage allowance is added.

Different weight packages were run with the machine; however, the 1-pound package was easiest to study, because it was easier for the operator to check the number of parts going into the box. Another reason for filling mostly 1-pound packages during the test was that the cooperating processing plant ran this size most frequently during the testing period.

[7] If the parts taken from bin F were all slightly lighter than the mean weight, the last piece would be selected from one of the bins on the right (heavy) side. The reverse would be true if the parts selected were all heavier than the mean weight.

Test Procedure for Experimental Machine

The experimental machine was tested for accuracy and operational qualities in the laboratory, using freshly processed chicken drumstick. After numerous laboratory tests and adjustment, the machine was installed in a commerical poultry processing plant. The tests here were designed to determine labor inputs as well as adjustments required under commercial operating conditions for box tare weights and variations in parts weight distributions.

Figure 6 shows the basic machine in place in the processing plant. The small conveyor mounted

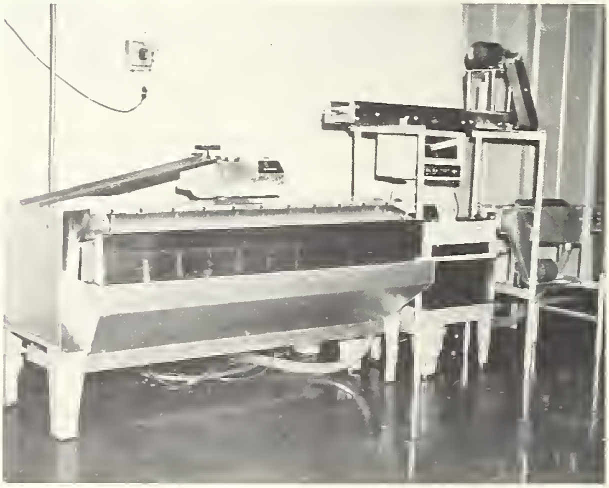

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FIGURE 6.—The experimental parts weighing and packing machine was installed in a poultry processing plant.

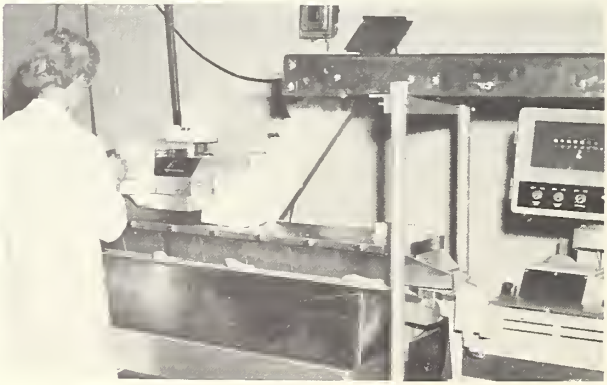

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FIGURE 7.—The operator was supplied with empty cartons by a chute attached to the back of the segregator.

over the classifier scales was used to return rejected packages of parts to the operator who fed parts on to the supply conveyor. The box chute from the hand scale sloping to the left end of the segregator was used to discharge full boxes. Another chute (fig. 7) was mounted in front of the operator so that empty cartons could be supplied in an orderly and continuous manner similar to facilities for commercial runs.

Figure 8 shows the test machine and auxiliary equipment in operation. The white platform scale at the left end of the machine was used to check the accuracy of the experimental operations. Each package was weighed and the exact weight recorded as a constant check on machine adjustment or operator error.

The pilot machine was set up in an area of the processing plant close to the line on which chickens were cut up so that parts were readily available. It was not placed in the production line, however, where plant production would be affected during the experimental runs. Batches of parts (drumsticks) were brought to the machine in quantities of 800 to 1,000 per lot for packaging. An operator experienced in packing parts packaged the parts, and research personnel supplied parts and cartons, checkweighed full cartons, and made machine adjustments.

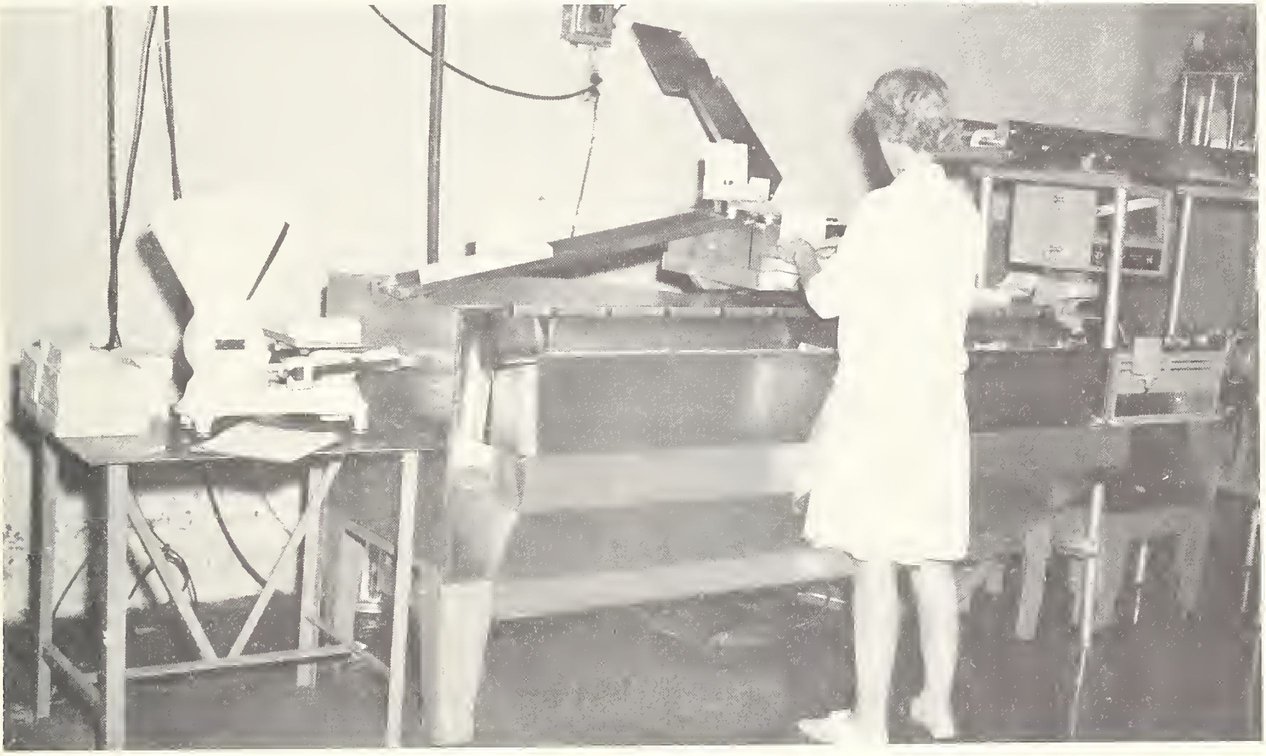

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Figure 8.—The experimental machine in operation, showing cartons being filled and moved on chute. At left are test scales that research personnel used for accuracy checks.

TEST RESULTS

Tests of the experimental weighing and packaging machine were designed to determine the reliability of selecting parts of a given range by presizing the chicken carcasses under commercial conditions. It was found, however, that parts from carcasses from many of the flocks did not always produce a normal distribution. Instead, the majority of the drumsticks would fall either to the left or to the right of the midpoint weight of the range, evidently because the 4-ounce carcass weight spread represented only a portion of the flock distribution and because the average flock weights varied.

The shift in distribution from one lot to another was shown in a series of tests conducted to determine the carcass size that would yield drumsticks of a weight suitable for packing 5, 6, 7, and 8 pieces per pound. One strain of chickens and a standard dismembering cut were used in the tests. (The carcasses weighed 26 to 40 ounces.)

During tests with 30- to 34-ounce carcasses, as many parts as possible were packed at seven pieces per pound. Then, when parts remained, they were packaged at six or eight parts per pound, depending on whether the leftover parts were light or heavy. Table 3 shows the results of packaging six lots of carcasses that weighed 30 to 34 ounces. Similar results were obtained when tests were run for determining carcass sizes that would yield 5, 6, and 8 drumsticks per pound.

TABLE 3.—*Results of packaging 6 and 7 drumsticks per pound from 6 lots of carcasses weighing 30 to 34 ounces*

Number of boxes packed per lot	7 pieces packed per pound	Drumsticks remaining after packing 7 per pound	6 pieces packed per pound	Drumsticks remaining after packing 6 and 7 per pound
	Boxes	*Percent*	*Boxes*	*Percent*
50	50	2. 8	0	2. 8
111	111	8. 0	0	8. 0
115	80	27. 7	35	. 6
113	63	42. 2	50	2. 9
87	87	6. 9	0	6. 9
113	107	17. 5	6	13. 5

Several tests were run using parts cut from birds with parts missing. Carcasses from these lots ran from one extreme in weight to the other (about 26 to 38 ounces). The test procedure for weighing and packaging drumsticks from these unsized birds was to set the machine for six parts per pound before running all the drumsticks across. First, only those parts falling in bins D through H were packaged. The machine was then reset for five parts per pound, and the heavier parts that had been diverted into bins I, J, and K were rerun through the machine and then packaged. The same procedure was followed for the parts that had fallen into bins A, B, and C, by packing eight parts per pound. When the packages with five and eight pieces per pound had been filled, most of the parts had been included. This procedure allowed packing most of the parts from carcasses ranging from 26 to 38 ounces in weight, leaving only a few extra heavy or extra light pieces. However, it was necessary to run most of the parts across the machine twice. One arrangement that could correct this situation is illustrated in figure 11 and discussed in "Conclusions and Applications."

Package Weights

Some difficulty was experienced in keeping the experimental equipment adjusted precisely to a very close tolerance in the damp atmosphere of the poultry plant. Further, allowances had to be made for the weight of small quantities of water on the classifier belt. Frequent checks and adjustments of electronic equipment were also required to compensate for variances caused by temperature fluctuation. However, as the tests progressed, it was found that frequent precise adjustment for each channel of the classifier was not necessary because minor errors tended to cancel each other. Moreover, weight of the final part selected by the machine was a check on the accuracy of the channel settings.

Table 4 shows that the weight above the marked net weight for 18 test runs (888 packages) averaged 0.119 ounce per package. Only on one run did the overweight average exceed the 0.2-ounce test tolerance. In this run, the lot average was 0.24 ounce per package—less than ¼-ounce overage. Five of the groups averaged less than 0.1 ounce per package excess weight. Compared with the manual operation, a saving of almost ½ ounce per pound package is possible. Using an average parts price of 35 cents per pound, a saving of approximately $100 per day is possible on a 10,000-pound-per-day operation.

TABLE 4.—*Results of packaging 18 lots of drumsticks on the experimental parts weighing and packing machine*

Net weight of box (Pounds)	Size of lot	Average excess weight per package [1]	
		Excess weight	Percentage of net weight
	Boxes	*Ounces*	*Percent*
1	59	0. 11	0. 7
1	44	. 16	1. 0
1	38	. 17	1. 1
1	59	. 03	. 2
1	71	. 14	. 9
1	47	. 12	. 8
1	20	. 16	1. 0
1	83	. 17	1. 1
1	20	. 24	1. 5
1	84	. 10	. 6
2	34	. 06	. 2
1	26	. 12	. 8
1	63	. 14	. 9
1	87	. 09	. 6
1	81	. 12	. 7
1	34	. 07	. 4
1	19	. 08	. 5
1	19	. 14	. 9

[1] Weighted average excess was 0.119 ounce for 888 packages. No excess was greater than ¼ ounce, and 5 of the lots averaged less than 1/10 ounce.

The last column in table 4 shows the excess weight expressed as a percentage of the marked net weight of the box. Only 5 of the 18 lots averaged 1 percent or over (maximum 1.5 percent), and 2 lots were only 0.2 of 1 percent.

In about half the test runs, some packages weighed less than the net weight marked on the box. However, the percentage of underweight packages was always low, and the weight seldom was more than 0.15 ounce under the net weight. There are several reasons why packages were occasionally outside of the 6-gram range objective. Machine maladjustment accounted for most of the deviations, but operator error and moisture weepage were additional factors. The following were the most common reasons: (1) Individual channels of the classifier were slightly out of adjustment, so that parts were placed in the wrong bin; (2) the mean weight of parts to be packaged was not set in the exact center of bin F; (3) the operator pushed the signal button before the hand scale settled, causing a signal to flash at the wrong bin; and (4) parts lost moisture after they were weighed and before they were packaged.

Rejected Boxes

Boxes were rejected and the parts were rerun if the signal light called for the last part to come from bin A or K, because the weight of parts in these bins was not confined to a 3-gram range. There were two main reasons for the machine to call for parts out of these bins in error: (1) The operator did not select the proper combinations of parts for the package, that is, she took too many from either side of bin F,[8] and (2) the classifier was not set with the mean weight of the distribution in the center of the range for bin F. The classifier setting had to be checked carefully at the start of each run. Adjustment was usually made on a trial-and-error basis by packing a few boxes and checkweighing them. However, neither of the errors was a serious problem, especially if the distribution of parts was normal.

The number of rejected boxes ran from 0 to 10 percent. The high percentage occurred primarily during the earlier tests before an adequate procedure for machine setting and adjustment was established.

Manual Versus Machine Packing Requirements

The experimental machine was built to test theories concerning methods and equipment for mechanically and electronically weighing and packaging chicken parts, including ways of reducing packaging labor costs and maintaining carton net weight without excessive overweight. The design encompassing all the requirements for the necessary experiments was not intended to produce maximum efficiency. Neither could the machine's performance be fairly compared with manual methods, because of the care of selecting parts to pack on the machine and the relatively small batch lots of parts, which were packaged out of line with other plant activities.

Time studies were made, however, of both types of operation, the manual and machine, to determine potential of such a machine when designed for commercial use.

Table 5 shows results from three studies of manual weighing and packing operations and two studies with the machine. The time values for obtaining and positioning the empty box did not vary greatly between the manual (average, 0.034 man-minute) and machine (average, 0.026 man-minute). The distance the operator had to reach was the greatest factor influencing the time value. The convenience of the box chute location on the machine is reflected in the lower time values.

The time it takes to "pack 5 to 6 drumsticks" is influenced by the availability of drumsticks and the distance the operator has to reach. Also, in some of the studies on the manual method, the operator had to select and separate drumsticks from other chicken parts on a conveyor belt. This accounts for some of the variation (from 0.105 man-minute to 0.142).

The time element "weigh box and select last piece" caused the greatest difference. During this element of work, labor requirements rose sharply, and overweight packages occurred frequently in the manual operation. The wide variation between elemental times for the manual method (0.070 to 0.202 man-minute) reflect the difficulty the operator had in finding the last piece for an exact weight. The time for the same element with the machine was 0.047 in one study and 0.051 man-minute in the other. With the machine, this element could not vary much because it consisted of pressing a button, picking up a part, and placing the part in the box.

Elemental times to close and place boxes aside were fairly constant for all studies. More time was required for the machine operation because the filled box had to be removed from the delicate hand-scale platform before it was closed.

The examples shown in table 5 are not necessarily typical industry rates for the manual methods of packing drumsticks, and those for the experimental machine should not be considered typical for a commercial machine. However, the examples do indicate the main differences between a manual and a machine operation.

[8] A shortcoming that can be overcome only with the development of operator skill and a sense of judgment through the use of the machine.

TABLE 5.—*Time required for packing 1-pound packages of drumsticks by manual methods and by the experimental mechanized weighing and packaging machine* [1]

Time element	Manual methods of packing poultry parts [2]			Mechanical weighing and packing machine [3]	
	Study 1	Study 2	Study 3	Study 1	Study 2
	Man-minutes	*Man-minutes*	*Man-minutes*	*Man-minutes*	*Man-minutes*
Obtain empty box and position on scale	0.034	0.032	0.037	0.027	0.024
Pack 5 to 6 drumsticks	.142	.124	.105	.101	.097
Weigh box and select last piece for exact weight	.202	.164	.070	.047	.051
Close lid and move box	.042	.036	.042	.055	.049
Total	0.420	0.356	0.254	0.230	0.221

[1] Studies for this comparison were limited to 1-pound packages.
[2] The studies were made in different processing plants with various packing station arrangements and drumsticks from various bird sizes.
[3] Drumsticks were from birds presized to provide six or seven drumsticks per pound package.

Packing Various Parts to Different Box Weights

Although the tests were set up for 1-pound boxes of drumsticks, other package sizes and different parts were packed. It was found that legs (fig. 9), wings, thighs, whole breasts, and split breasts could be weighed and segregated into weight groups as readily as drumsticks. Even large whole breasts could be easily segregated into the 3-gram differences of the 33-gram spread to which the machine was designed.

The success of the machine with all types of parts has important implications because of the vast amount of portion-controlled product sold in institutional packages.[9] For example, large quantities of parts from unsized birds could be run across such a machine and parts of any specified weight range could rapidly and accurately be separated from the lot.

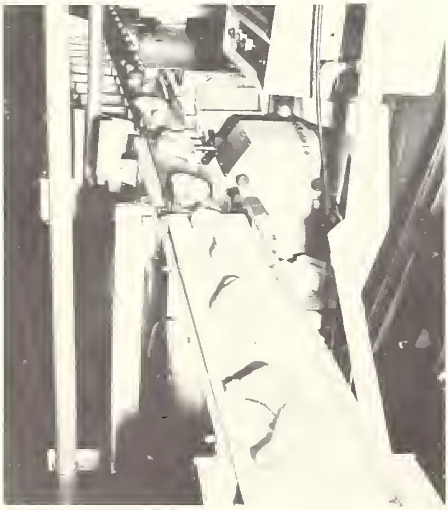

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FIGURE 9.—Chicken legs (drumstick and thigh joined) were weighed and segregated by installing a longer scale platform on the classifier.

The scale platform originally placed on the classifier was about 7½ inches long, which was adequate for weighing drumsticks. A longer platform was constructed and installed on the machine for weighing and segregating legs and breasts. The longer platform (about 12 inches) reduced the capacity of the machine because wider spacing of the parts on the weighing belt was required to allow one part to clear the scale platform before the next part reached it. No particular problems were encountered in running these larger parts, except that the belts on the classifier and segregator were a little narrow for some of the larger pieces.

One batch of whole legs from presized carcasses was run with the scales adjusted and set so that parts weighing 214 grams (7.52 oz.) were discharged into bin F (fig. 1). Although there were not enough parts to provide a smooth distribution curve, about 60 percent of the parts fell in bins B through J.

Wings and thighs offered no serious problems, except occasionally thighs had long trailing pieces of skin that tended to impede the passage of parts from one conveyor to another. The wings used were from presized carcasses. Bin F was set at a mean weight of 70 grams (2.46 oz.) in this instance; this mean weight resulted in a very good distribution. All the parts fell within bins B through J.

[9] Packed in bulk packages, they meet the need of stewards, chefs, dieticians, and so forth, requiring precise portion control.

Data from these tests showed the extent of overlapping in weight ranges for various numbers of parts per package for both 1- and 2-pound packages (fig. 10). For example, parts in the weight range required for 12 pieces per pound (mean weight, 37.8 grams) would be found (in decreasing numbers) among parts making up the weight ranges for 11, 10, 9, 8, and 7 parts per pound. The weight range shown in the chart for each number of parts per package is the same as that used for the experimental machine—33 grams. Each range is found by first dividing the number of parts into the package net weight to obtain the mean weight; then 16.5 grams (0.58 oz.) is added to the mean weight to obtain the heavy end of the range, and 16.5 grams is subtracted from the mean weight to obtain the light end.

This overlapping of weight ranges occurs most frequently among parts of lighter weight. Because of this overlapping of small parts, it would be easier to pack small containers with small parts. The number of parts per package should be predetermined, however; if 12 pieces per pound were packed from a lot, packing 9, 10, or 11 pieces per pound from the parts remaining would be practically impossible. Packing eight pieces per pound from the same lot would also be difficult because most of the lightweight pieces would have been used in the packages containing the small parts.

Greater difficulty is encountered in arriving at exact weights when packing a small number of large parts, because the selectivity is much less with a limited or absence of overlap. As package weight increases, this problem decreases. In figure 10, the mean weight of each weight range would represent the setting for the center bin, F (fig. 1), on the experimental machine. The broken line extending downward through other ranges shows the extent of overlapping of the 33-

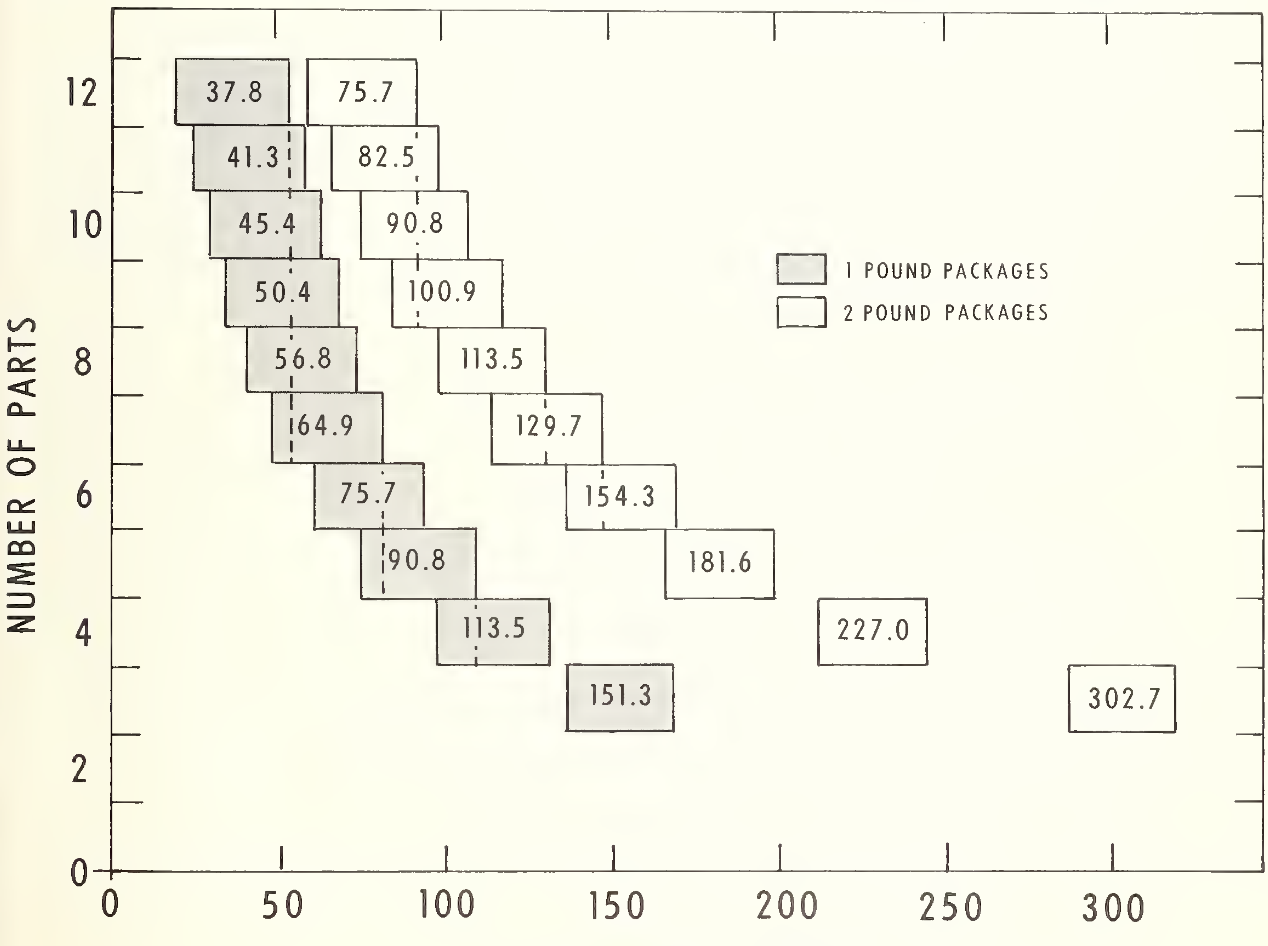

FIGURE 10.—Overlap in weight ranges by number of parts packed in 1- and 2-pound packages. (Figures in boxes are expressed as mean weight.)

gram weight range for boxes of varying numbers of parts.

CONCLUSIONS AND APPLICATIONS

Based on the limited but positive test results, the decrease in both labor requirements and amount of overweight in packages of poultry meat would be sufficiently significant to warrant mechanization to reduce processing costs.

Mechanized weighing and packing of chicken parts to any desired package weight is more accurate and less costly for labor than manual weighing and packing. A large-volume plant with a uniform production schedule would benefit most from mechanized weighing and packing. Only with this arrangement could the equipment be fully utilized.

Two methods can be followed in a mechanized weighing and packing operation:

1. Parts can be packed from presized carcasses that are selected to yield the best combinations of parts for specific package weights.
2. Parts can be cut from unsized carcasses and segregated into specific weight ranges for packaging.

The greatest advantage of the first method is that the specific weights of parts from a given lot of sized carcasses can be predicted rather accurately. However, carcasses selected to provide a good combination for packing drumsticks may not make a good weight combination for packing breasts. One other advantage of this method is that most plants already have sizing equipment, and sizing of carcasses for this purpose will incur little or no extra cost.

The main advantage in using the second method is that birds with parts missing from trimming must be cut up without sizing anyway. Therefore, cutting up all unsized carcasses would eliminate special handling of parts-missing birds. Another advantage of the second method is that the weight range of parts would be wide, and certain sizes could easily be selected by electronic weighing devices for any package weight desired. Thus, by routing all parts across segregators, flexibility in package weight and size would be great. This method appears to be feasible for future mass production. Figure 11 is a sketch of how the equipment might be laid out for such an operation. In this layout it is assumed that the packers would move from one work station to another, depending upon where the greatest number of parts accumulated from time to time. Thus, an operator would not be needed for each work station shown.

To justify full mechanization of the weighing and packing of parts, a company would need to have (1) a large volume of product, since the machinery would have to be at least partially customized, (2) continuous mass production schedules without frequent changes in operations, and (3) sales or outlets with sufficient diversification to absorb small lots that remained after packing a major portion of the parts.

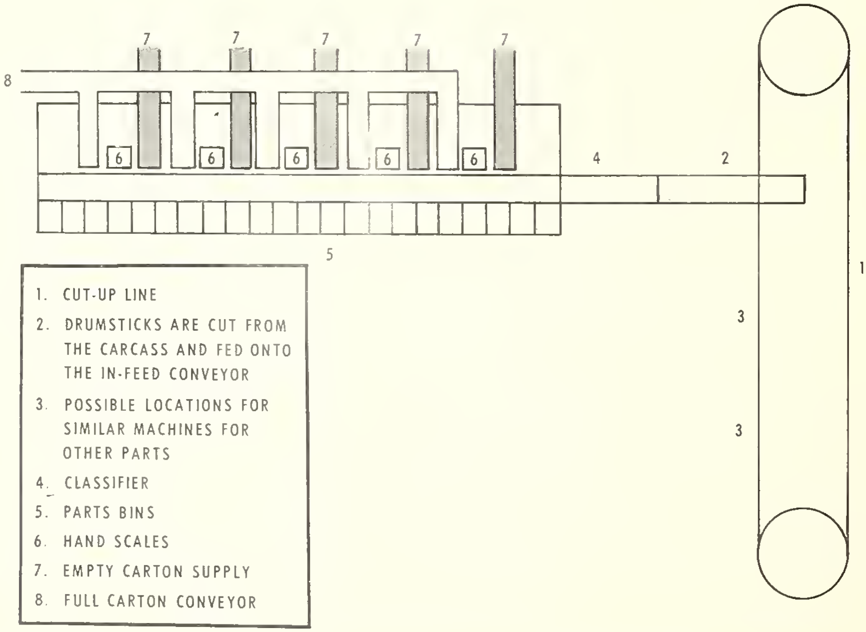

FIGURE 11.—A packing machine layout which would allow packaging of parts from unsized carcasses involving a wide range of parts weight.

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